PAYLOAD FLIGHT HAZARD REPORT				a. NO:	AMS-02-F08
b. PAYLOAD	Alpha Magnetic Spectrometer-02 (AMS-02)			c. PHASE:	II
d. SUBSYSTEM:	Electrical	e. HAZARD GROUP:	Electric Shock. Injury/Illness	f. DATE:	March 31, 2006
g. HAZARD TITLE:	Electric Shock/Discharge			i. HAZARD CATEGORY:	CATASTROPHIC **X** CRITICAL
h. APPLICABLE SAFETY REQUIREMENTS:	NSTS 1700.7B and ISS Addendum, paragraph 102.1, 200.1b				
j. DESCRIPTION OF HAZARD:	Incidental contact by an EVA crewmember with the high voltages and currents of the AMS-02 systems (TRD, TOF, ACC, Tracker, RICH, ECAL, Cryocooler and the Cryomagnet) could result in damage to the EMU/Orlan and/or physiological effects on the crewmember. Electrical Discharge of high voltage sources through a rarified atmosphere can damage EVA equiment, payload hardware, SSP and ISS systems and injure the EVA Crew. Table of HV Applications Attached				
k. CAUSES *(list)*	1. Defective design, component, wire, insulation and/or workmanship 2. Exposed terminals, Connectors, energized conductive surfaces. 3. Coronal Discharge				

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III		

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l. HAZARD CONTROL (CONTROL), m. SAFETY VERIFICATION METHODS (SVM), n. STATUS OF VERIFICATIONS (STATUS)		OPS CONTROL
1. CAUSE: Defective design, component, wire, insulation and/or workmanship		
1.1 CONTROL: All AMS-02 EVAs (contingency only) will take place when the AMS-02 is unpowered and the magnetic field (stored energy) has been discharged. On the shuttle, only the power must be removed, the AMS-02 can not charge the magnet while in the Shuttle payload bay. 1.1.1 SVM: Review of Procedural controls to have power removed before any EVA Access of AMS-02 while on the Shuttle. 1.1.2 SVM: Review of Procedural controls to have power removed and magnet (stored power) discharged for any EVA Access of AMS-02 while on the ISS. 1.1.1 STATUS: Open 1.1.2 STATUS: Open		I, S
1.2 CONTROL: The UPS batteries will remain operational during EVAs, but the design of the AMS-02 electrical system isolates the UPS from the Avionics power system and EVA access. The UPS is isolated from the AMS-02 power system (from powering the system) by blocking diodes, Solid State Power Conditioner, HV Transformer barrier (galvanic isolation), control electronics power transformer with galvanic isolation and blocking diodes in the Battery Management System. The UPS powers only the Cryomagnet avionics for magnet protection, this circuitry is not accessible to the EVA Crew. 1.2.1 SVM: Review of design for AMS-02 Power Distribution System isolation from UPS. 1.2.2 SVM: Review of design for UPS powered circuitry isolation from EVA. 1.2.3 SVM: QA certification of as built hardware for AMS-02 Power Distribution System and UPS built to drawings/design. 1.2.1 STATUS: Open 1.2.2 STATUS: Open 1.2.3 STATUS: Open		
1.3 CONTROL: Defective components, wires and insulation will be screened out by inspection of the individual components as they are received and installed.		

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1.3.1 SVM: Review of Design. 1.3.2 SVM: Inspection of as built hardware. 1.3.1 STATUS: Open 1.3.2 STATUS: Open	
1.4 CONTROL: HV insulation and potting will be selected to be compatible with the HV source voltages and for compatibility with the operating environment. 1.4.1 SVM: Review of Design. 1.4.2 SVM: Inspection of as built hardware. 1.4.1 STATUS: Open 1.4.2 STATUS: Open	
2. CAUSE: Exposed terminals, connectors, energized conductive surfaces.	
2.1 CONTROL: All exposed connectors will either have automatic covers that preclude contact with energized circuits when demated (UMA), or diodes and drain resistors will be used to prevent presence of power at unshielded connectors (ROEU-PDA, PVGF). 2.1.1 SVM: Review of design. 2.1.2 SVM: Functional testing of covers. 2.1.3 SVM: Testing of exposed connectors for proper diode blocking. 2.1.1 STATUS: Open 2.1.2 STATUS: Open 2.1.3 STATUS: Open	
2.2 CONTROL: All AMS-02 electrical components will be grounded/bonded through the AMS-02 Unique Support Structure through nickel plated guide vanes and through the nominal power distribution system. These grounding paths to the Orbiter shall be in accordance with NSTS 21000-IDD-ISS, Rev A. Grounding paths to the ISS upon installation will be made through the Payload Attach System (PAS) per SSP 57003A. 2.2.1 SVM: Review of design.	

2.2.2 SVM: Testing of integration grounding of AMS-02 Components to integration hardware. 2.2.3 SVM: Testing of Interface paths to the Shuttle and ISS (UMA & Nickel Plated Guide Vanes). 2.2.1 STATUS: Open 2.2.2 STATUS: Open 2.2.3 STATUS: Open	
2.3 CONTROL: All high voltage power supplies (>120VDC) will be located in fully potted avionics boxes that are properly grounded to the AMS-02 structure and grounding paths. 2.3.1 SVM: Review of Design. 2.3.2 SVM: Testing of enclosure's grounding path connectivity. 2.3.1 STATUS: Open 2.3.2 STATUS: Open	
2.4 CONTROL: The TRD high voltage (1600VDC maximum) components implement high voltage insulation and potting to control high voltage exposure. HV power supply for the TRD is current limited to 20nA per channel. The TRD will be covered by a grounded MLI blanket enclosing the entire TRD octagon. 2.4.1 SVM: Review of design for potting and insulation of high voltage sources. 2.4.2 SVM: Inspection of flight hardware to assure proper potting and insulation 2.4.3 SVM: Review of Design for MLI grounding points to structure. 2.4.4 SVM: Testing of MLI grounding resistance 2.4.1 STATUS: Open 2.4.2 STATUS: Open 2.4.3 STATUS: Open	
2.5 CONTROL: PMT applications utilize potting and conformal coating to preclude exposure of high voltage connectors, components and wiring. PMTs are isolated from any potential exterior contact. Cabling carrying high voltages to the PMTs are all space rated and qualified for voltages in excess to the maximum voltages present. 2.5.1 SVM: Review of design for potting and insulation of high voltage applications and wiring.	

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2.5.2 SVM: Inspection to verify that there is no exterior accessibility of the PMT or their circuitry. 2.5.3 SVM: Inspection of flight hardware to assure proper use of potting and high voltage wiring. 2.5.1 STATUS: Open 2.5.2 STATUS: Open 2.5.3 STATUS: Open		
2.6 CONTROL: The Orbiter side of the ROEU (GFE hardware) will be depowered for the disconnect operation and remain unpowered once the umbilical is separated from the AMS-02. Any EVA subsequent to this separation could come in contact with this connector. AMS-02 procedures will call out the removal of power and will not include any procedures that will require power to be resumed to the connector without reconnection of the ROEU to the ROEU-PDA. Design of the ROEU connector is certified GFE and is being used within its certification. 2.6.1 SVM: Review of Crew Procedures to assure procedures call for removal of power from ROEU. 2.6.1 STATUS: Open		S
2.7 CONTROLS: Avionics, heaters and Cryocoolers operating from up to 120 VDC from the ISS or Shuttle APCU utilizes properly insulated wiring/cabling that are potted/conformally coated to preclude incidental shorting. Insulation rating of the heaters minimized the potential for shorting or exposing high voltages. 2.7.1 SVM: Review of HV designs. 2.7.2 SVM: Review of 120V heater design. 2.7.1 STATUS: Open 2.7.2 STATUS: Open		
3. CAUSE: Coronal Discharge		
3.1 CONTROL: During ascent and entry, high voltage sources will not be powered. The AMS-02 will only operate a superfluid helium valve during ascent by baroswitch and computer based-timer, no high voltage systems will be operated. The AMS-02 UPS system is 32 VDC. 3.1.1 SVM: Confirmation of AMS-02 Status prior to launch, science systems unpowered for launch. 3.1.2 SVM: Review of Crew Procedures for contingency return of the AMS-02 with the Orbiter to assure that the high voltages to the AMS-02 are turned off.		S

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3.1.1 STATUS: Open 3.1.2 STATUS: Open	
NOTE: During operation of HV sources, the AMS-02 will be venting Helium and losing TRD gases (Xenon, Carbon Dioxide). The immediate environment about the AMS-02 will likely be an extremely rarified gas and potentially conducive to the lowering of Coronal Onset Voltage (COV).	
NOTE: The potential effects of coronal discharges upon the AMS-02 are degradation of HV circuitry and EMI, conducted and radiated, "white noise" being generated. All HV sources will be depowered as a consequence of nominal power removal when any EVA involving the AMS occurs on the ISS. All corona potential zones will be covered and isolated from exterior equipment.	
3.2 CONTROL: AMS-02 high voltage sources will be potted and conformally coated and/or insulated using high voltage insulating compounds. All cabling carrying high voltage utilizes insulation that is properly rated for the voltages that are to be carried. High voltage systems will implement the design practices suggested in MSFC-STD-531 to minimize the potential for corona effects. 3.2.1 SVM: Review of design. 3.2.2 SVM: Inspection of as built hardware. 3.2.3 SVM: Corona testing/analysis. 3.2.4 SVM: Functional testing of AMS-02 in flight configuration in thermal-vacuum chamber. 3.2.1 STATUS: Open 3.2.2 STATUS: Open 3.2.3 STATUS: Open 3.2.4 STATUS: Open	
Notes:	

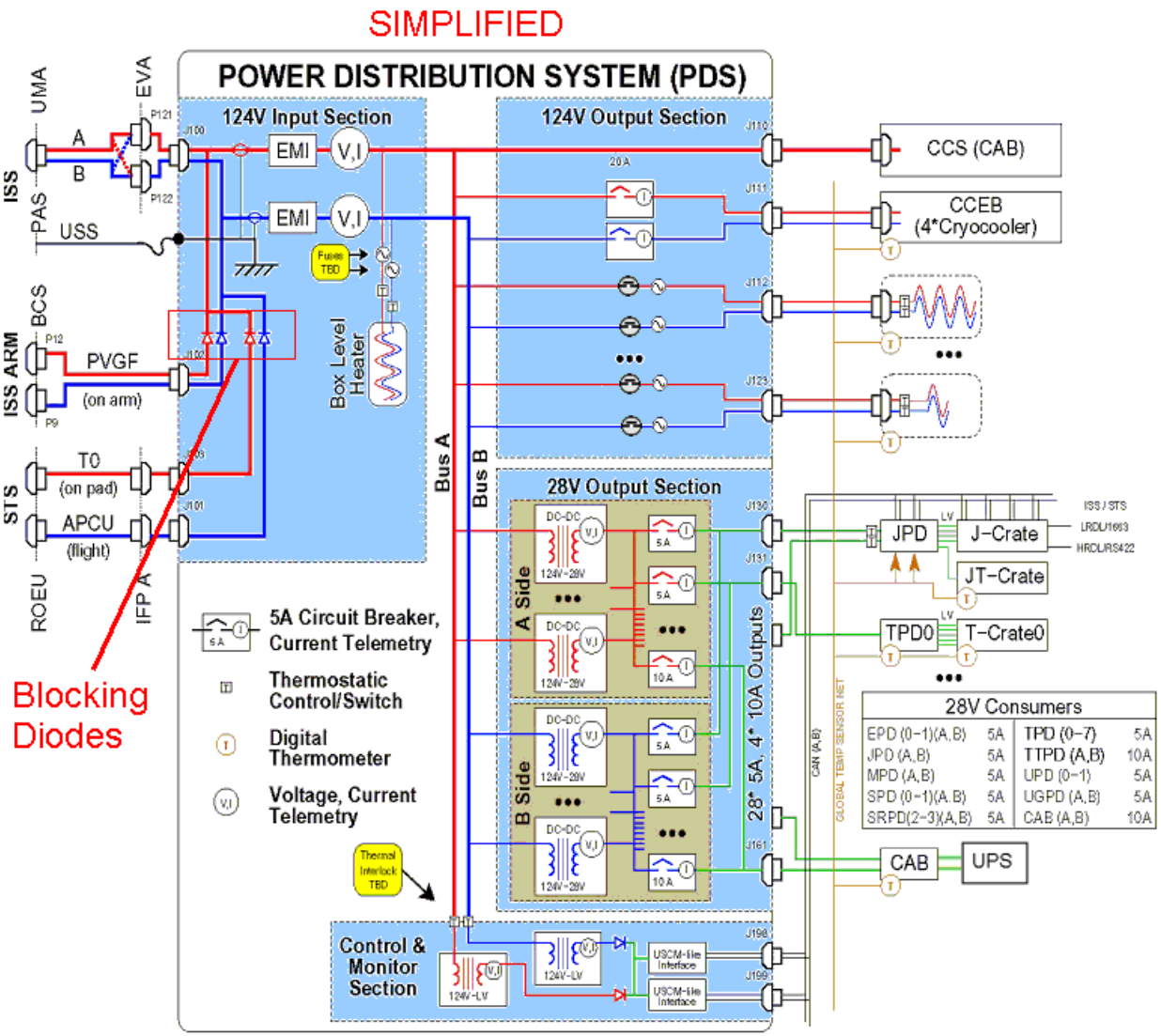
ACRONYMS	
ACC – Anti-Coincidence Counter	PAS – Payload Attach System
AMS-02 – Alphamagnetic Spectrometer 02	PDS – Power Distribution System
APCU – Auxillary Power Control Unit	PMT – Photomultiplier Tube
CAB – Cryomagnet Avionics Box	PVGF – Power Video Grapple Fixture
CC1, CC2, CC3, CC4	RHVx – RICH High Voltage (brick)
CCEB – Cryocooler Electronics Box	RICH – Ring Imagining Cherenkov (detector)
CCS – Cryomagnet Current Source	ROEU – Remotely Operated Electrical Umbilical
CDD-P, S – Cryomagnet Dump Diodes (Port, Starboard)	ROEU-PDA - Remotely Operated Electrical Umbilical Power Data
COV – Coronal Onset Voltage	SHVx – S-Crate High Voltage (brick)
	SVM – Safety Verification Method
CSP – Cryomagnet Self Protection	TBS
ECAL – Electromagnetic Calorimeter	TOF – Time of Flight
EHVx – ECAL High Voltage (brick)	TPD – Tracker Power Distribution
EMI – Electromagnetic Interference	TRD – Transition Radiation Detector
EVA – Extravehicular Activity	UHVG -
GFE – Government Furnished Equipment	UMA – Umbilical Mating Adapter
HV – High Voltage	UPD -
LTOF – Lower Time of Flight	UPS – Uninterruptible Power Supply
LUSS – Lower Unique Support Structure	UTE
MLI – Multilayer Insulation	UTOF – Upper Time of Flight
nA – nano Ampere	V – Volts

High Voltages (and Currents) in AMS-02.			M.Capell	06-22-05		
Item	**Subsystem**	**Source**	**Load**	**Voltage**	**Current**	**AWG**
1	Cryocooler	CCEB	Cryocooler 1	<90VAC	<2.5A	**22**
2	Cryocooler	CCEB	Cryocooler 2	<90VAC	<2.5A	**22**
3	Cryocooler	CCEB	Cryocooler 3	<90VAC	<2.5A	**22**
4	Cryocooler	CCEB	Cryocooler 4	<90VAC	<2.5A	**22**
5	Cryomagnet	CCS in CAB	Charge Patch Panel	<10VDC	<460A	0
	Cryomagnet	Charge Patch Panel	Cryomagnet	<10VDC	<460A	**TBD**
6	Cryomagnet	Cryomagnet	CDD-P, CDD-S	<10VDC	<460A	0
7	Cryomagnet	UPS-0	CSP in CAB	<32VDC	<90A	12
9	Cryomagnet	UPS-1	CSP in CAB	<32VDC	<90A	12
8	Cryomagnet	CSP in CAB	Quench Heaters	<32VDC	<90A	12
10	Cryomagnet	CSP in CAB	Quench Heaters	<32VDC	<90A	12
	Cryomagnet	Cryomagnet	Quench Detectors 1-9	<1KV	<1A	24
	Cryomagnet	Cryomagnet	Quench Detect. 10-18	<1KV	<1A	24
11	ECAL	EHV0-0	55 ECAL PMTs	<1000VDC	<250uA	Coax-36
12	ECAL	EHV0-1	55 ECAL PMTs	<1000VDC	<250uA	Coax-36
13	ECAL	EHV0-2	55 ECAL PMTs	<1000VDC	<250uA	Coax-36
14	ECAL	EHV1-0	55 ECAL PMTs	<1000VDC	<250uA	Coax-36
15	ECAL	EHV1-1	55 ECAL PMTs	<1000VDC	<250uA	Coax-36
16	ECAL	EHV1-2	55 ECAL PMTs	<1000VDC	<250uA	Coax-36
17	Interface	ISS	AMS	120VDC	<25A	8
18	Interface	ISS/PVGF	AMS	120VDC	<15A	12
18	Interface	ISS/T0	AMS	120VDC	<25A	12
19	Interface	STS/APCU	AMS	120VDC	<25A	8
20	Power	PDS	CCS in CAB	120VDC	<20A	12
21	Power	PDS	CCEB	120VDC	<7.5A	12
22	RICH	RHV0-0	40 RICH PMTs	<1000VDC	<80uA	Coax-36
23	RICH	RHV0-1	40 RICH PMTs	<1000VDC	<80uA	Coax-36
24	RICH	RHV1-0	40 RICH PMTs	<1000VDC	<80uA	Coax-36

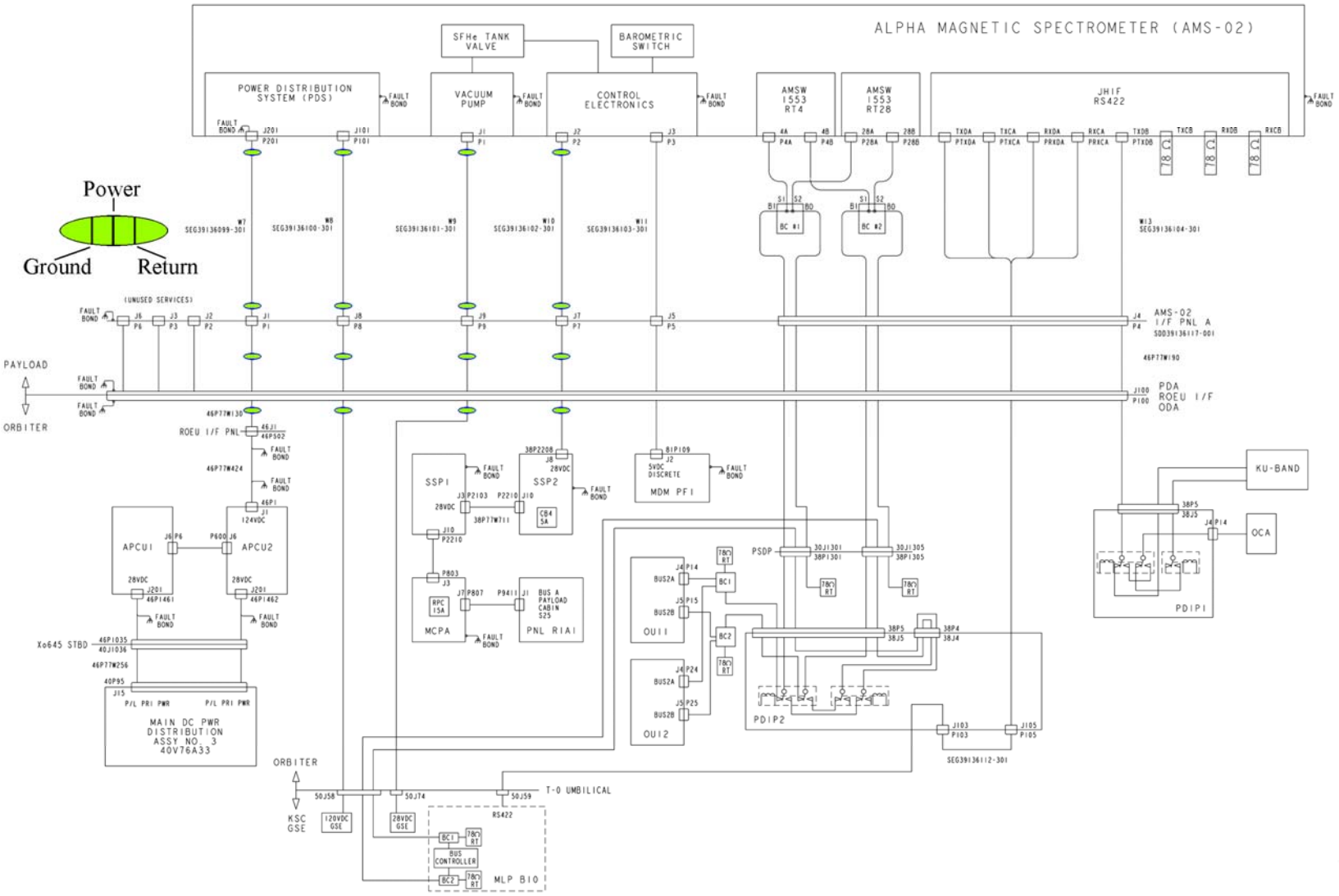
High Voltages (and Currents) in AMS-02.				M.Capell	06-22-05	
Item	**Subsystem**	**Source**	**Load**	**Voltage**	**Current**	**AWG**
25	RICH	RHV1-1	40 RICH PMTs	<1000VDC	<80uA	Coax-36
26	S:TOF+ACC	SHV0	34 TOF+4 ACC PMTs	<2500VDC	<50uA	Coax-36
27	S:TOF+ACC	SHV1	34 TOF+4 ACC PMTs	<2500VDC	<50uA	Coax-36
28	S:TOF+ACC	SHV2	38 TOF+4 ACC PMTs	<2500VDC	<50uA	Coax-36
29	S:TOF+ACC	SHV3	38 TOF+4 ACC PMTs	<2500VDC	<50uA	Coax-36
30	Thermal	PDS	ECAL Heaters	120VDC	<3A	20
31	Thermal	PDS	Ram Heaters	120VDC	<7.5A	20
32	Thermal	PDS	TRD Heaters	120VDC	<3A	20
34	Thermal	PDS	Tracker Wake Heaters	120VDC	<3A	20
35	Thermal	PDS	Wake Heaters	120VDC	<5A	20
37	Thermal	PDS	LUSS Boxes	120VDC	<3A	20
41	Thermal	PDS	RICH Heaters	120VDC	<3A	20
42	Thermal	PDS	LTOF Heaters	120VDC	<3A	20
43	Thermal	PDS	CC1&2 Heaters	120VDC	<3A	20
45	Thermal	PDS	Tracker Ram Heaters	120VDC	<3A	20
46	Thermal	PDS	CC3&4 Heaters	120VDC	<3A	20
48	Tracker	TPD0	2 TBS in T0-Crate	<120VDC	<10mA	22
49	Tracker	TPD1 in TSPD1	2 TBS in T1-Crate	<120VDC	<10mA	22
50	Tracker	TPD2 in TMPD2	2 TBS in T2-Crate	<120VDC	<10mA	22
51	Tracker	TPD3 in TSPD3	2 TBS in T3-Crate	<120VDC	<10mA	22
52	Tracker	TPD4 in TSPD4	2 TBS in T4-Crate	<120VDC	<10mA	22
53	Tracker	TPD5	2 TBS in T5-Crate	<120VDC	<10mA	22
54	Tracker	TPD6 in TSPD6	2 TBS in T6-Crate	<120VDC	<10mA	22
55	Tracker	TPD7	2 TBS in T7-Crate	<120VDC	<10mA	22
56	Tracker	2 TBS in T0-Crate	24 Tracker Ladders	<80VDC	<10mA	26
57	Tracker	2 TBS in T1-Crate	24 Tracker Ladders	<80VDC	<10mA	26
58	Tracker	2 TBS in T2-Crate	24 Tracker Ladders	<80VDC	<10mA	26
59	Tracker	2 TBS in T3-Crate	24 Tracker Ladders	<80VDC	<10mA	26
60	Tracker	2 TBS in T4-Crate	24 Tracker Ladders	<80VDC	<10mA	26

High Voltages (and Currents) in AMS-02.			M.Capell	06-22-05		
Item	**Subsystem**	**Source**	**Load**	**Voltage**	**Current**	**AWG**
61	Tracker	2 TBS in T5-Crate	24 Tracker Ladders	<80VDC	<10mA	26
62	Tracker	2 TBS in T6-Crate	24 Tracker Ladders	<80VDC	<10mA	26
63	Tracker	2 TBS in T7-Crate	24 Tracker Ladders	<80VDC	<10mA	26
64	TRD	UPD0	6 UHVG in U0-Crate	<120VDC	<35mA	22
65	TRD	UPD1	6 UHVG in U1-Crate	<120VDC	<35mA	22
66	TRD	6 UHVG in U0-Crate	2624 TRD Straw Tubes	<1800VDC	<100uA	Coax-36
67	TRD	6 UHVG in U1-Crate	2624 TRD Straw Tubes	<1800VDC	<100uA	Coax-36
68	TRD-Gas	UPD0	UHVG in U0-Crate	<120VDC	<35mA	22
69	TRD-Gas	UHVG in UG-Crate	4 Rad Monitor Tubes	<1800VDC	<100uA	Coax-36

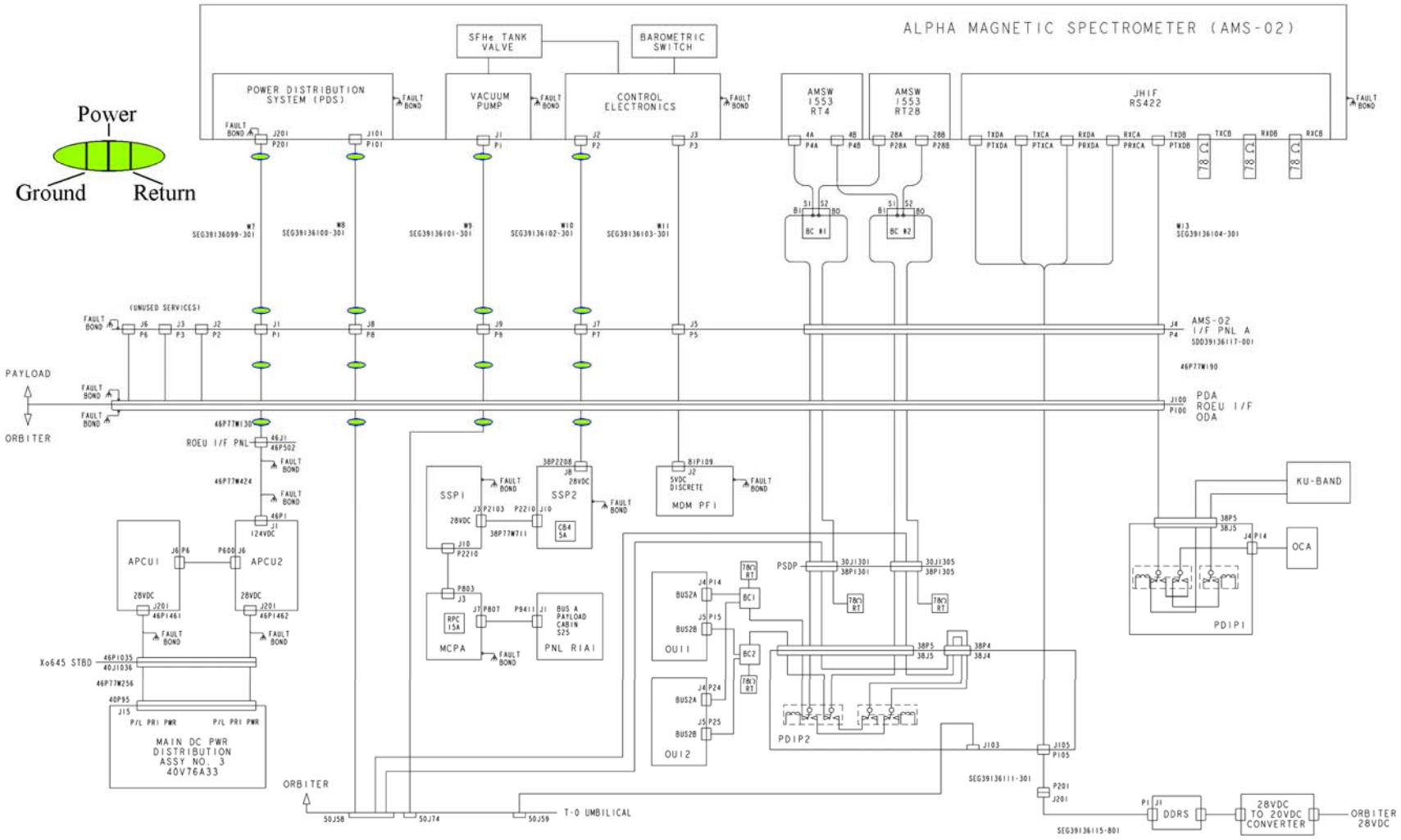
ISS, STS Voltages after EMI filter



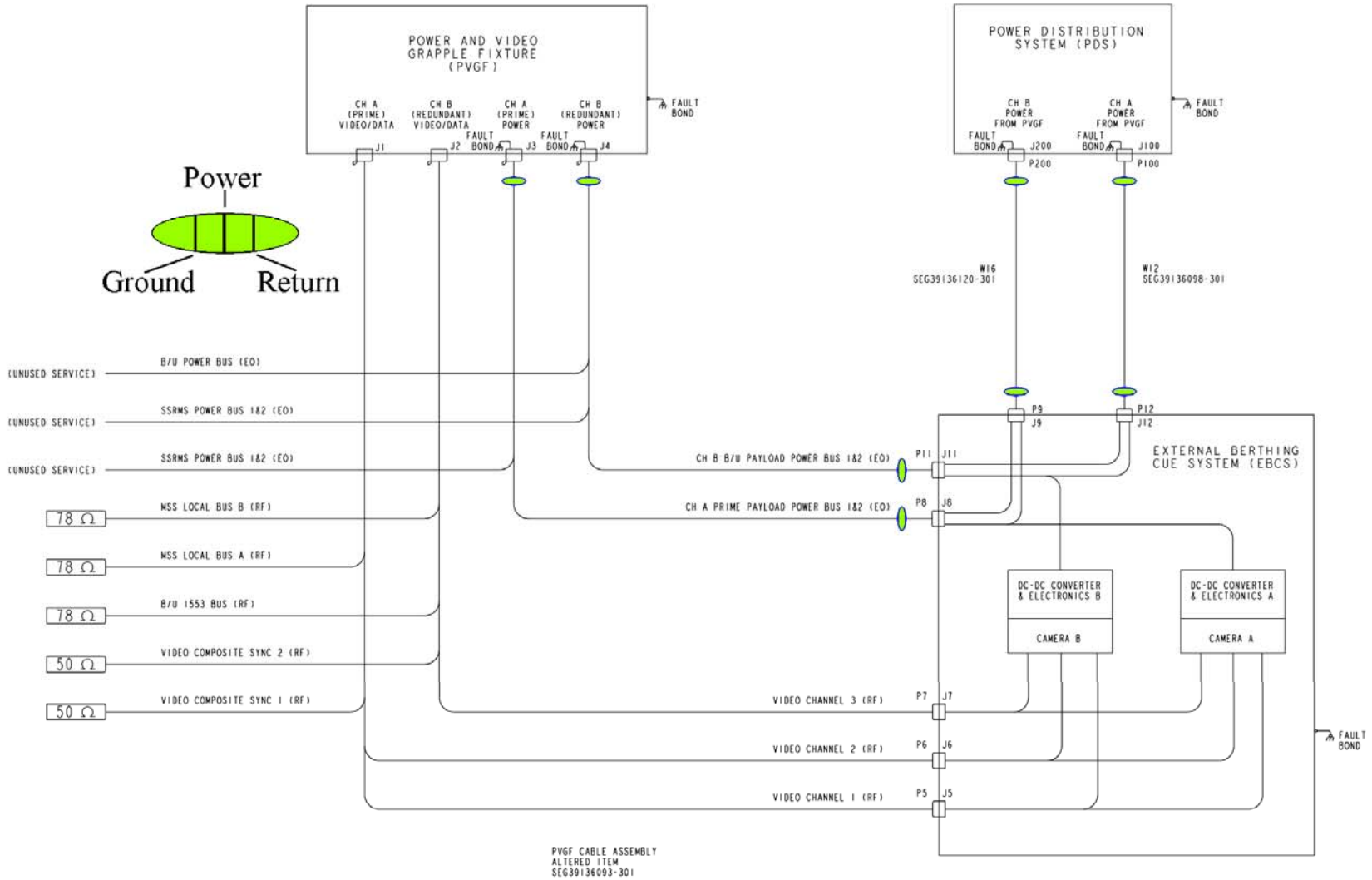
Blocking Diodes isolating ROEU and PVGF connectors from alternate power sources.



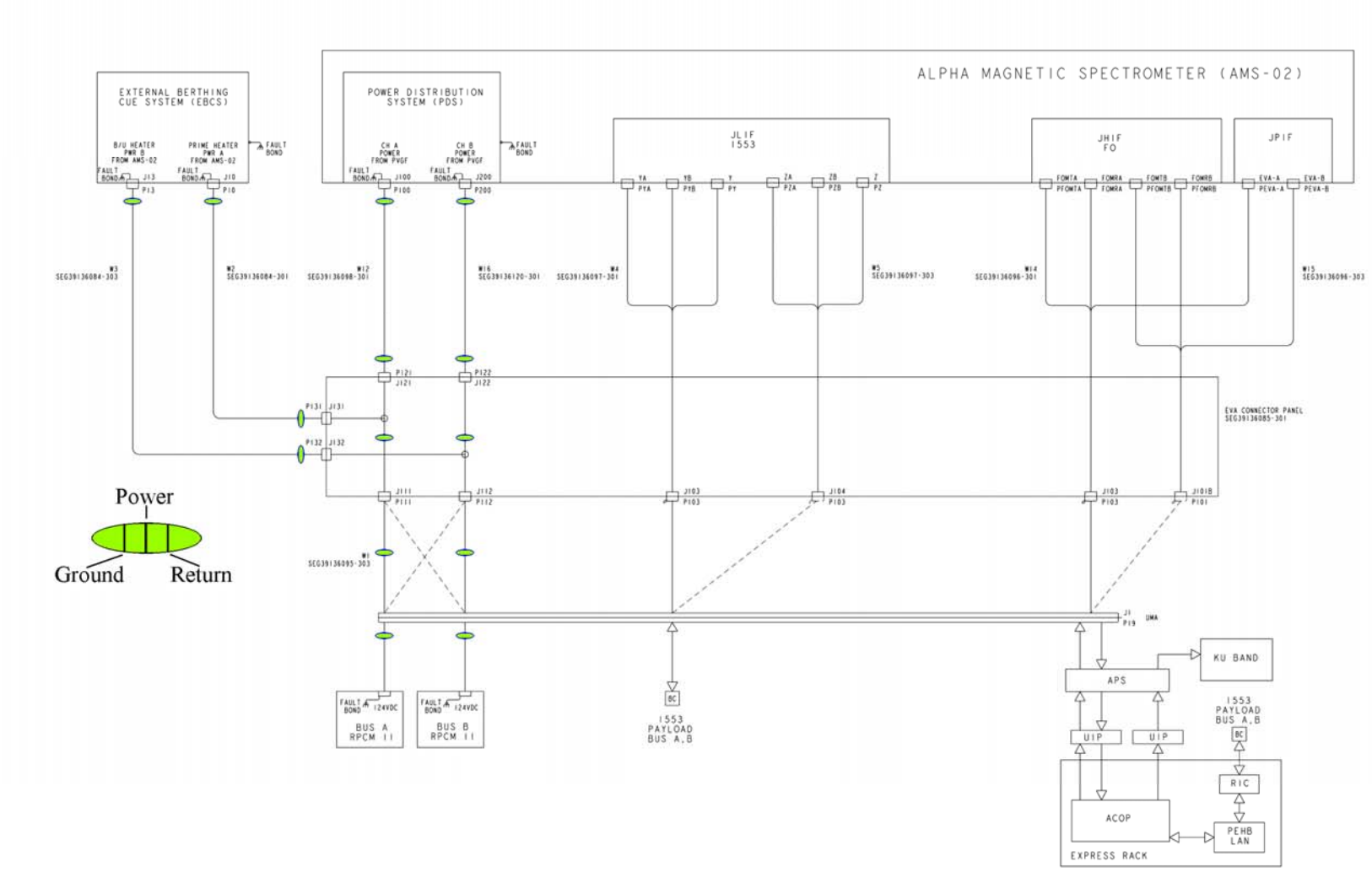
AMS-02 Power Interface with T-0 Power



AMS-02 Power Interface with STS Orbiter

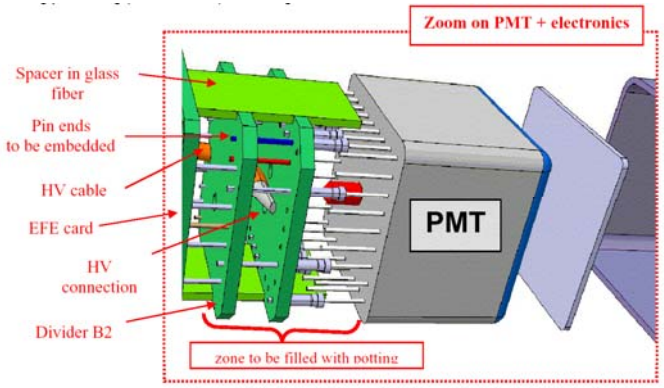


AMS-02 Power Interface with Space Station Remote Manipulator System

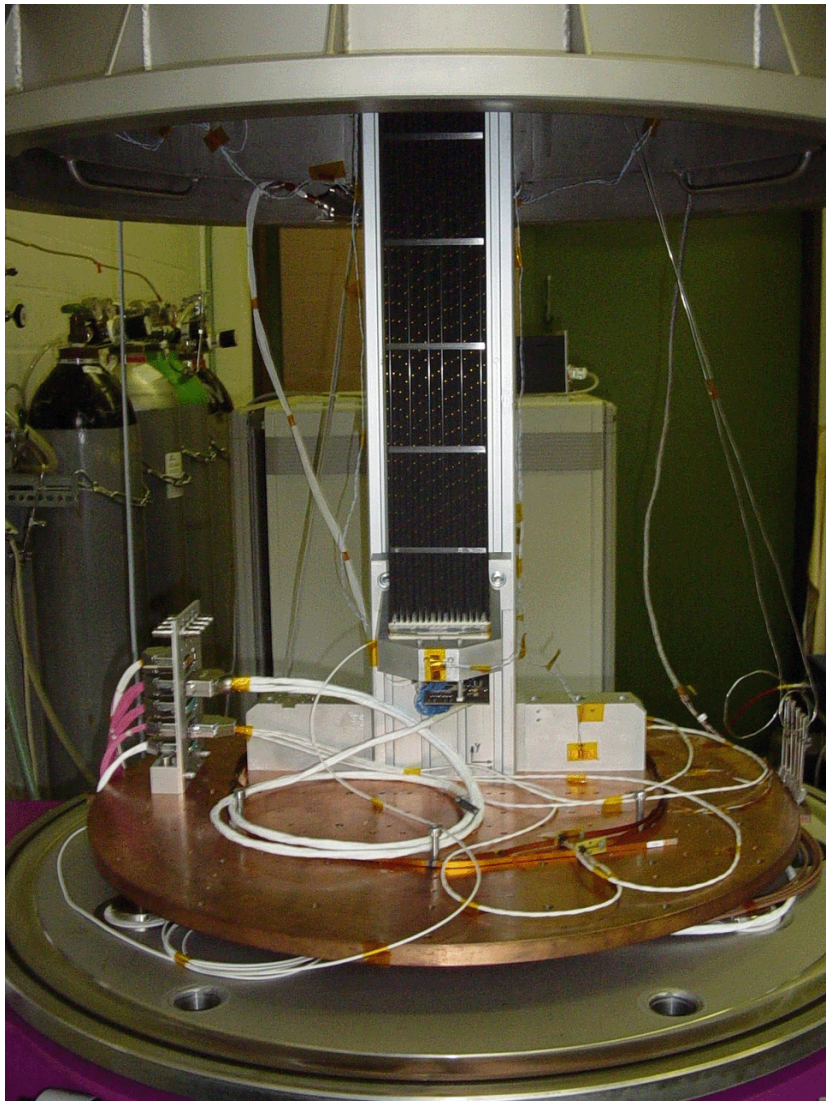


AMS-02 Power Interface with ISS at berthing location

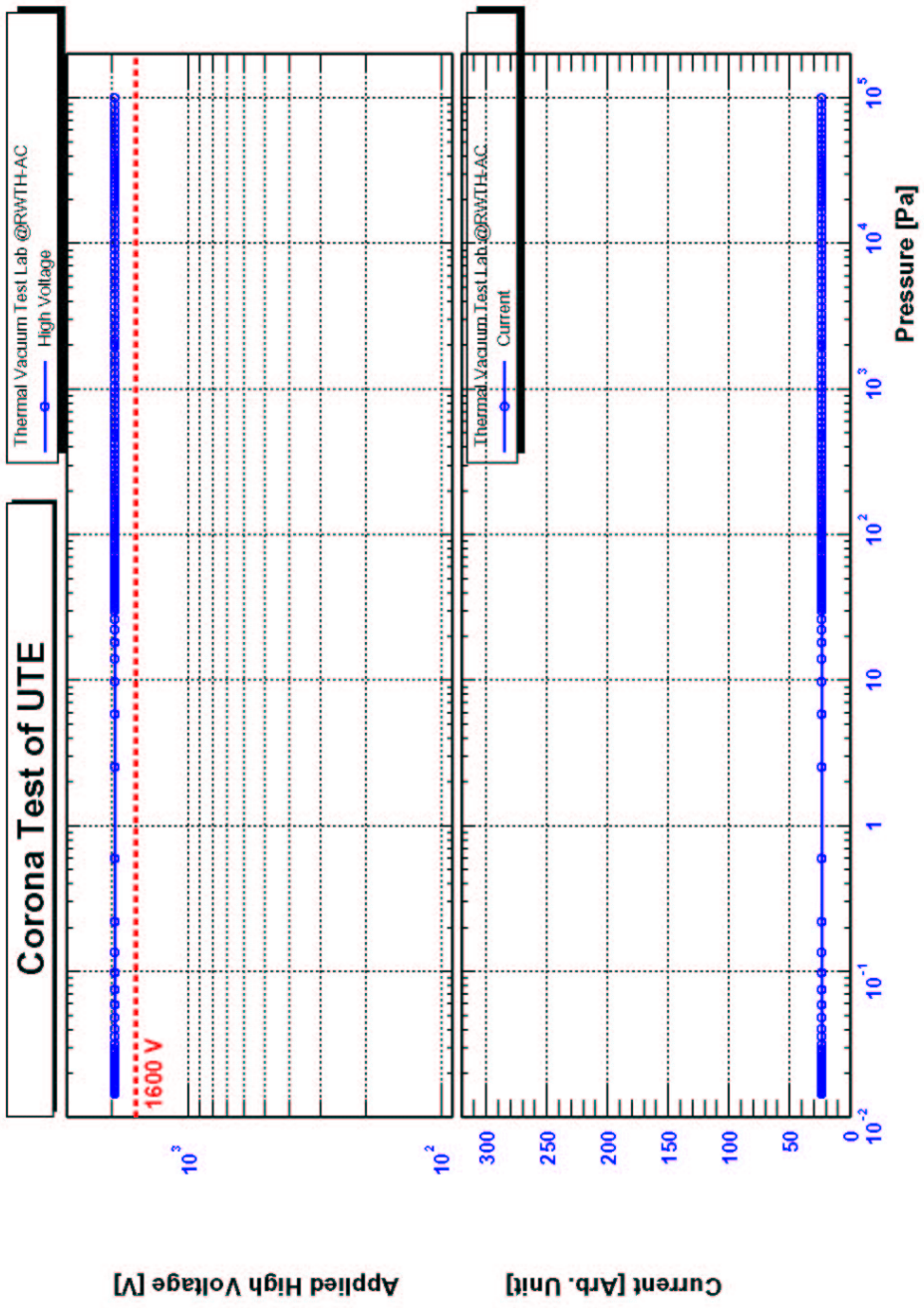
Example of High Voltage Component Potting.
RICH Photo Multiplier Tube



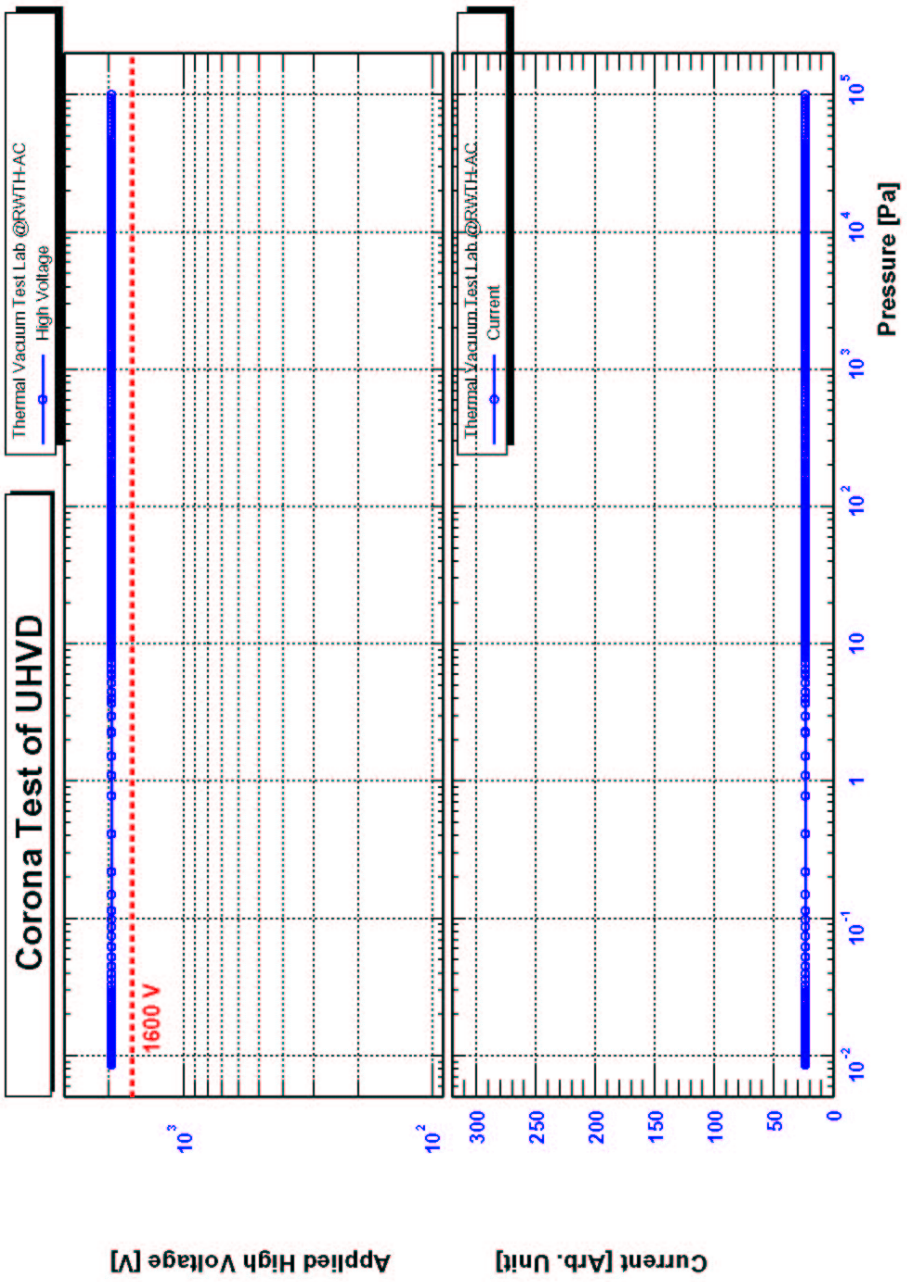
Example of High Voltage Component Potting.
RICH Photo Multiplier Tube Potting Zone



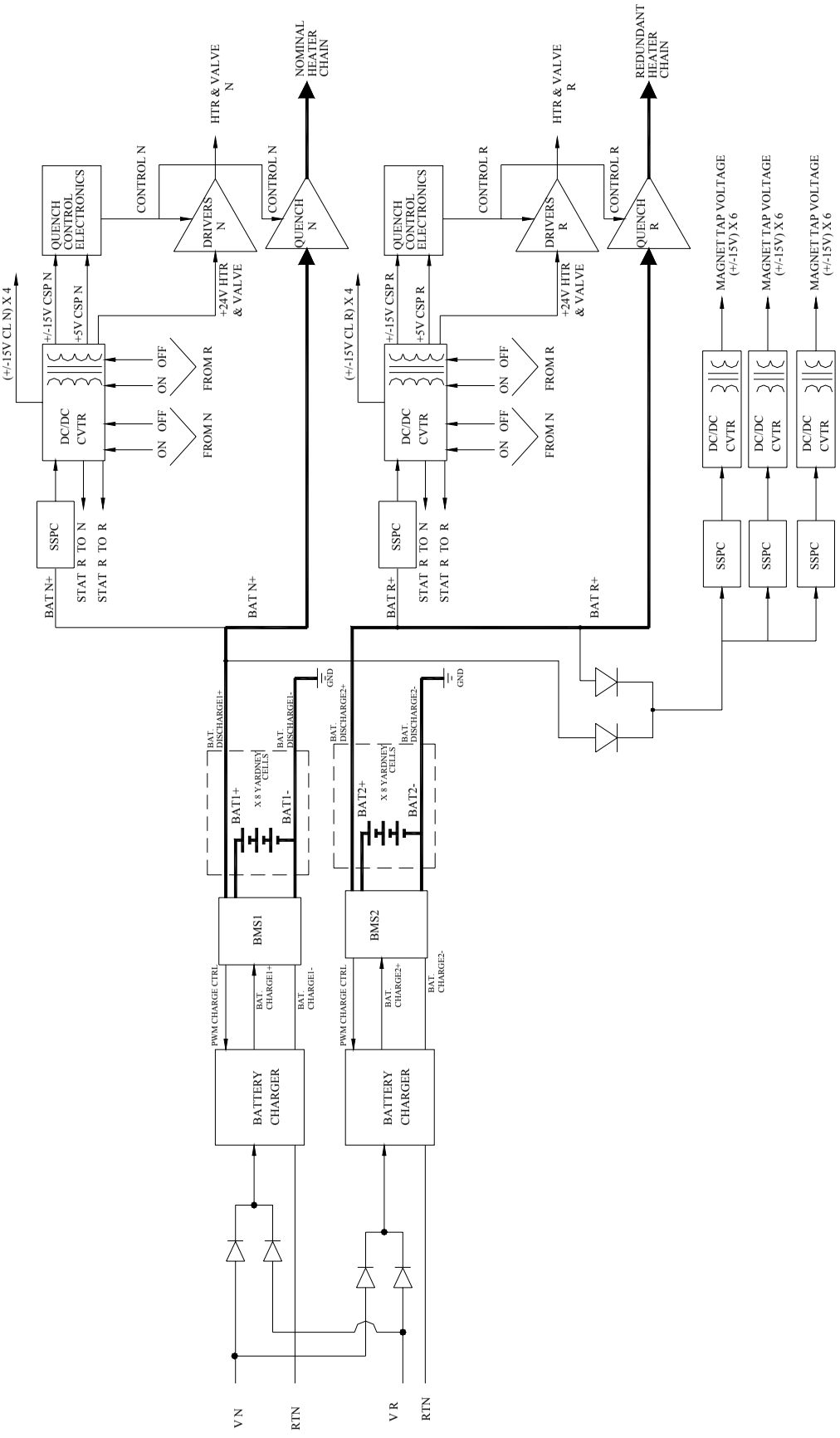
Coronal Discharge Testing of TRD High Voltage Straws.



Corona Test Results for TRD UTE



Coronal Testing Results for TRD UHVD



Battery Isolation from Power Distribution System